STATE OF CALIFORNIA

Specification
for
Profilable Thermoplastic Traffic Striping Material,
White and Lead-Free Yellow

1.0 SCOPE

This specification covers a hot-melt, retroreflective thermoplastic pavement marking material that is suitable for producing durable, profiled traffic stripes and pavement markings on Portland cement concrete or asphalt concrete pavements. The material is heated and applied to road surfaces in a molten state using a mechanical applicator. Immediately after application to the pavement, glass beads are applied and a profiled surface is imparted to the hot thermoplastic stripe using various mechanical means. Upon cooling to normal pavement temperatures, the resulting traffic striping shall be retroreflective, firmly bonded to the pavement and have a surface profile that matches the required dimensions. The profiled stripe shall be resistant to deformation by traffic.

2.0 APPLICABLE SPECIFICATIONS

The following specifications, test methods and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

- California Test Method, CT 423.
- California Department of Transportation, Standard Specifications, latest revision.
- Federal Standard 595B, color #33538
- American Association of State Highway and Transportation Officials, (AASHTO) Designations: M 247
- American Society for Testing and Materials, (ASTM) Designations: D 476, D 3335, D 3718, D 4563, D 4764, D 5380, D 6359, E 11, E 1710, and G 155.
- Commission International de l'Eclairage (C.I.E.) 1931 Chromaticity Diagram.
- California Code of Regulations Designation: Title 22.

3.0 REQUIREMENTS

3.1 Composition:

The thermoplastic material shall be composed of 100% solids. The binder shall consist of synthetic hydrocarbon or alkyd thermoplastic resins which are homogeneously blended together with all necessary pigments, fillers, glass beads and additives to produce a traffic striping material that meets the requirements as specified herein. All thermoplastic material shall be free from; lead, chromium, cadmium, barium and other toxic metals.

3.1.1 White Material:

White thermoplastic shall contain a minimum of 10% (by weight) titanium dioxide pigment meeting ASTM Designation: D476 Type II (Rutile). The titanium dioxide

*This specification cancels and supercedes; specification PTH-02PROFILE(dated Apr. 03) and PTH-499A (April 1999).

content will be determined using ASTM Designations: D 4563, D 4764, D 5380 or other x-ray diffraction analysis method.

3.1.2 Lead-Free Yellow Material:
Lead-Free (L/F) yellow thermoplastic shall contain proper amounts of C.I. Pigment Yellow 83 (opaque version) and titanium dioxide (Rutile) to produce a material that has a weather-fast and heat stable yellow color which meets the requirements as stated herein. Other pigments may be added to achieve these color requirements. The L/F yellow thermoplastic material shall appear yellow during both daytime and nighttime conditions when applied with drop-on glass beads.

3.1.3 Other Ingredients:
The remainder of the thermoplastic composition shall be determined by the manufacturer - within the constraints of the requirements below. It shall be the manufacturer's responsibility to produce a thermoplastic material containing the necessary plasticizers, antioxidants, and other additives so that the thermoplastic will retain its color, viscosity and all other properties as specified herein. In addition to being essentially lead and chromium free, the thermoplastic shall not contain any hazardous materials at levels that would cause the thermoplastic to be classified as a hazardous waste under Title 22, Division 4, section 66261.20 of the California Code of Regulations.

3.2 **Form:**
The thermoplastic material shall be supplied in either block or granular form as requested in the purchase order.

3.3 **Application Type:**
The thermoplastic material shall be formulated for profiled application and shall have suitable viscosity and thixotrophy to allow proper application at the recommended temperatures.

3.4 **Characteristics of the Finished Thermoplastic:**
Use CT 423 unless otherwise specified. The melting and stirring apparatus (see Figure 8) differs slightly from that shown in CT 423. Once the material is melted, the speed of the mixing blade should be at least 160 revolutions per minute.

		White	L/F Yellow
3.4.1	Glass Bead Content, intermixed, meeting AASHTO Designation: M 247 Type I, percent by weight, minimum,	30	30

		White	L/F Yellow
3.4.2	Binder Content, percent by weight, minimum.	18	18

		White	L/F Yellow
3.4.3	Inert Fillers, insoluble in hydrochloric acid,	100	100

percent by weight passing a U.S. Standard No. 100 sieve, minimum, ASTM Designation: E 11.

		White	L/F Yellow
3.4.4	Titanium Dioxide (Rutile) Pigment meeting ASTM Designation: D476 Type II, analyze titanium dioxide content using ASTM Designation: D 4563, D 4764, D 5380 or other x-ray diffraction method, percent by weight, minimum.	10	---

		White	L/F Yellow
3.4.5	Specific Gravity, maximum,	2.15	2.15

		White	L/F Yellow
3.4.6	Ring and Ball Softening Point,	93-121°C	93-121°C

3.4.7 **Perform the remaining tests on the material after 4 hours heating** with stirring at 218 ± 2°C. These 4 hours include time required (~1 hr.) for melting and temperature stabilization of the 6000 g (13 lb) sample.

		White	L/F Yellow
3.4.7.1	Tensile Bond Strength to an unprimed portland cement concrete brick, 125 mil thick film draw down at 218°C, test at 25 ± 2°C, psi, minimum,	180	180

		White	L/F Yellow
3.4.7.2	Brookfield Thermosel Viscosity, Spindle SC4-27, 2.5 rpm at 218°C, Poise, minimum,	300	300

		White	L/F Yellow
3.4.7.3	Viscosity Shear Ratio, minimum, determine Brookfield Thermosel Viscosity as in 3.4.7.2 above except at 0.5 rpm and 2.5 rpm (at 218°C). Calculate Viscosity Shear Ratio as:	3	3

$$\text{Viscosity Shear Ratio} = \frac{\text{viscosity at 0.5 rpm}}{\text{viscosity at 2.5 rpm}}$$

		White	L/F Yellow
3.4.7.4	Impact Resistance, 125 mil thick film draw down at 218°C on an unprimed portland cement concrete brick. Test at 25 ± 2°C, inch-pounds,	50	50

		White	L/F Yellow
3.4.7.5	Daytime Luminance Factor	80 Minimum	42 to 59

		White	L/F Yellow
3.4.7.6	Yellow Color shall match Federal Standard 595B, color #33538 and shall lie within the following chromaticity limits "colorbox" defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram; (x1,y1) = (0.5125, 0.4866) (x2,y2) = (0.4865, 0.4647) (x3,y3) = (0.5000, 0.4416) (x4,y4) = (0.5348, 0.4646) See an example of the Yellow Color chart in Figure 9.	---	Pass

		White	L/F Yellow
3.4.7.7	Yellowness Index, maximum	10	---

3.4.7.8 Color Stability after Accelerated Weathering, ASTM Designation: G 155, Table X3.1, Cycle 1. Prepare sample by dipping an aluminum panel into the molten thermoplastic and removing it to obtain a 60 to 120 mil coating thickness of thermoplastic on the panel. Place the panel in the weathering apparatus for 500 hrs. After accelerated weathering, measure the Yellow Color or Yellowness Index as in section 3.4.7.6 or 3.4.7.7 above. Material must meet the color stability requirements below after this exposure.

		White	L/F Yellow
White -	Yellowness Index, maximum	20	---
Yellow -	Measured chromaticity coordinates must fall within a "colorbox" defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram. (x1, y1) = (0.5125, 0.4866) (x2, y2) = (0.4650, 0.4466) (x3, y3) = (0.4750, 0.4251) (x4, y4) = (0.5348, 0.4646)	---	Pass

		White	L/F Yellow
3.4.7.9	Hardness, Shore A-2 Durometer,	20 to 75	20 to 75

		White	L/F Yellow
3.4.7.10	Abrasion Test, total weight loss, grams, maximum	10	10

		White	L/F Yellow
3.4.7.11	Lead, mg/kg in thermoplastic, maximum, ASTM Designation: D3335	20	20

		White	L/F Yellow
3.4.7.12	Chromium, mg/kg in thermoplastic, maximum, ASTM Designation: D3718	5	5

		White	L/F Yellow
3.4.7.13	Initial Retroreflectivity of applied thermoplastic striping (with glass beads), $mcd \bullet m^{-2} \bullet lx^{-1}$, minimum	250	175

The thermoplastic shall produce delineation and pavement markings that have the required minimum level of retroreflectivity when applied with drop-on glass beads. Drop-on glass beads shall be uniformly applied at a minimum rate of 8 lbs of beads per 100 square feet of thermoplastic. The retroreflectivity shall be measured as specified in ASTM Designation: D6359 using a retroreflectometer meeting ASTM Designation: E1710.

3.4.7.14 Color after Application

The daytime color of the applied white and yellow thermoplastic traffic stripes and pavement markings (with drop-on beads) shall meet the color requirements in section 3.4.7.8 (Color Stability after Accelerated Weathering). The color shall be measured within 60 days of application using a portable BYK-Gardner "Color-Guide" Spectrophotometer.

3.5 Other Requirements:

3.5.1 Slump Test

3.5.1.1 Purpose:

The ability of the applied profiled material to resist leveling while hot is described below.

3.5.1.2 Summary:

Using a specialized slump test die box (Figure 4), a stripe of the molten thermoplastic material is extruded onto a concrete brick leaving profiled grooves in the thermoplastic surface. The widths of these grooves are measured after the material has cooled to determine if excessive leveling has occurred.

3.5.1.3 Apparatus:

A die box shall be formed that is enclosed on three sides utilizing 1/8 inch x 2 inch flat steel stock (Figure 4). The parts shall be welded together to form a screed box. One edge of this box shall have gaps (openings) milled as shown in Figure 4. These gaps will produce a profiled thermoplastic line to be extruded when the die box is moved across the concrete brick. The rear of the die shall be joined together using a piece of ½ inch diameter round steel stock. A handle can be affixed in order to move the die box (Figure 4). A forced air oven maintained at 218°C ± 2°C, a ladle and a abrasive-blasted concrete brick as described in CT 423, Part 7,will also be needed. Measurement of the width of the profiled groove can be done using a caliper.

3.5.1.4 Procedure:

The specialized die box (Figure 4) is placed in a 218°C ± 2°C oven and allowed to equilibrate to oven temperature. The abrasive-blasted concrete brick is placed on a sturdy workbench and allowed to reach 25°C ± 2°C. The melted thermoplastic sample

from the tests in section 3.4.7 is maintained at 218°C for 2 to 4 hours with stirring from the time the sample becomes completely melted.
Working quickly to avoid excessive cooling, remove the hot die box from the oven and place it on one end of the concrete brick (Figure 1). Quickly ladle approximately 350 gm of the hot thermoplastic sample into the die box reservoir (Figure 1). Draw the die box along the 7-inch length of the concrete brick in a smooth motion requiring approximately 3 seconds (Figure 2). Continue drawing the die box along and off the edge of the concrete brick (Figure 2). This should form a profiled stripe of thermoplastic on the face of the brick. Allow the thermoplastic to cool to room temperature and measure the width of the profiled grooves in the thermoplastic stripe using a caliper to determine the distance between the vertical faces of each groove at the bottom of the groove (Figure 3). Measure this distance at 3 different places in each groove of the profiled stripe. The average distance between the vertical faces of a passing sample shall be greater than 5.00 mm.

3.5.2 Compression Test

3.5.2.1 Purpose:

The ability of the thermoplastic material to resist deformation, while under a load and at typical hot pavement temperatures, is described below.

3.5.2.2 Summary:

The hot thermoplastic material is cast in a rectangular mold and allowed to cool. The sample is removed from the mold and placed in an oven with a static load on top of the sample. After 4 hours the deformation of the sample is measured.

3.5.2.3 Apparatus:

A rectangular steel form shall be fabricated from 5/8 inch square bar stock steel (Figure 5). The form shall be assembled at the corners with socket head cap screws for easy disassembly. The inside dimensions of the form shall be 5/8 inch x 4 inches. Also required are; a standard 2 x 3 1/2 x 8 inches red clay construction brick weighing 2500 g ± 200 g, an 8 inch square piece of ¼ inch thick Masonite board, a forced air oven maintained at 85°C ± 2°C, silicone mold release spray and silicone release paper.

3.5.2.4 Procedure:

Assemble the mold and spray the interior surfaces with the mold release spray. Center the mold on the Masonite hardboard and place on a level surface. Fill the mold slightly more than level full with hot thermoplastic material heated to 218°C ± 2°C in accordance with section 3.4.7. Strike off the excess thermoplastic to form a flat surface on the top of the sample. Allow the sample to cool for at least 4 hours before removing the mold. Leave the molded sample on the Masonite board. Measure the surface area of the top face of the rectangular thermoplastic sample. Cover the top of the sample with a piece of silicone release paper slightly larger than the sample itself. Place the large face of the brick squarely on top of the molded sample, centering the brick on top of the sample (Figure 6). Place the Masonite board, thermoplastic sample, silicone release paper and brick in an 85°C forced air oven for 4 hours. At the end of 4 hours remove the sample from the oven and remove the brick from the sample. Allow the sample to cool to room temperature and measure the surface area of the top face of the thermoplastic

sample (Figure 7). The surface area shall increase by no more than 10% above the initial surface area.

3.5.3 Workmanship:
The materials ingredients (resins, pigments, glass beads, fillers and additives) shall be homogeneously blended. The finished product shall be uniform from bag to bag. The melted thermoplastic material shall have no indications of resin separation or incompatibility of resins when melted or after cooling. The material shall be free from all; dirt, water, foreign matter, and other deleterious substances capable of clogging; screens, valves, pumps and other striping apparatus. The thermoplastic material shall be of such composition that it will not bleed, stain, or discolor when applied to pavements.

3.5.4 Shelf Life:
The material shall maintain the requirements of this specification for a minimum period of one (1) year from the date of manufacture. Any materials failing to do so shall be replaced at the expense of the manufacturer. Ordered thermoplastic shall be no more than 120 days old (based on date of manufacture) upon delivery to a Department of Transportation Maintenance facility. The date of manufacture shall be clearly marked on each bag of thermoplastic.

3.5.5 Applicability:
The thermoplastic material shall completely melt to a homogeneous fluid that is free of debris. The molten thermoplastic material shall be readily applied at temperatures between 400°F and 450°F. The material shall have suitable viscosity and thixotrophy to allow proper profiled application. The applied stripe shall retain its profiled height and shape and shall not flow or become deformed while cooling or when bearing traffic. Upon application to the pavement, the thermoplastic material shall be sufficiently tack-free to carry traffic; in not more than 2 minutes when the pavement surface temperature is 60°F, and in not more than 10 minutes when the pavement surface temperature is 130°F.

3.5.6 Air Pollution Compliance:
This material shall comply with all applicable air pollution control rules and regulations. The thermoplastic material shall not emit fumes that are toxic or injurious to persons or property when it is heated to application temperature. The material shall not emit excessive smoke during heating or application.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Inspection and Sampling:

All thermoplastic material intended for use by the California Department of Transportation (Department) must be sampled, tested and approved by the Transportation Laboratory **before** shipment.

Manufacturers shall take representative samples of each lot of thermoplastic and ship the samples to the Transportation Laboratory. Two (duplicate) 6000 g (13 lb) samples of

each lot of thermoplastic are required to be sent to the Transportation Laboratory for testing.

A lot shall consist of a batch or consecutive batches of thermoplastic manufactured on the same day using the same formulation. A batch shall be that amount of thermoplastic that was manufactured and packaged in a single operation. Thermoplastic from the same lot shall be palletized, shrink-wrapped, labeled with the manufacturer's lot and batch numbers (on each pallet) and batch number (on each bag) and stored in a common area to facilitate random sampling of the entire lot by the Inspector. A lot shall be more than 2000 lbs and shall be less than 44,000 lbs of thermoplastic.

Manufacturers must submit the following information along with the two representative 6000 g samples of each lot for testing.

1. State Specification number (PTH-02PROFILE).
2. Manufacturer's Product number
3. Color; (White or Lead-Free Yellow) and lbs represented by samples.
4. Identification numbers of batches comprising the lot and lot number.
5. Date of manufacture.
6. Form (block or granular).
7. Binder Type (hydrocarbon or alkyd).
8. Sampling method (splitting, thieving, quartering, random bag, etc.).
9. Purchase Order or Contract number.

A manufacturer's test report shall also be included with the representative duplicate samples of each lot sent to the Transportation Laboratory. The following information shall be included in the manufacturer's test report:

- Hardness
- Binder Content
- Glass Bead Content
- Daytime Luminance Factor
- Yellow Color (for yellow only)
- Yellowness Index (for white only)

The samples and above information shall be sent to the Transportation Laboratory at the address listed in section 6.4. A Certificate of Compliance (see section 6.1) shall accompany the samples.

Once the Transportation Laboratory approves a lot of thermoplastic, the manufacturer will be notified that the lot is approved for shipment.

When shipments of the approved lots/batches of thermoplastic are made to a Department Maintenance facility, the manufacturer shall fax the following information to the Transportation Laboratory within 48 hours of the shipping date. Out of State

manufacturers shall also fax the following information to the Transportation Laboratory whenever shipments of approved lots/batches are shipped to warehouses, resellers, or Contractors within the State of California.

- State Specification number (PTH-02PROFILE).
- A list of each delivery locations and delivery dates.
- Name and phone number of contact person(s) at the delivery location(s).
- Colors, batch/lot numbers and quantity of material comprising shipment.
- Purchase Order number or Contract number and date that order was received.

This information shall be faxed to: Transportation Laboratory, Chemical Testing Branch, 5900 Folsom Blvd., Sacramento, CA 95819, attn.: Lisa Dobeck, Fax (916) 227-7168.

The Department reserves the right to take random samples of lots/batches of thermoplastic destined for use by the Department, at the manufacturer's facility. Sampling may also be done at the Contractor's warehouse or jobsite. If requested by the Inspector, batch tickets must also be provided for batches of thermoplastic produced for the Department.

The Department also reserves the right to retest any batch/lot of thermoplastic after delivery. Results from such retesting shall prevail over all other tests and may be the basis of rejection. Material not meeting the specification shall be removed and replaced by the supplier at their expense, including all costs for handling, retesting and shipping.

4.2 **Testing:**

All tests shall be performed according to the latest revision of the specified test methods. Qualitative and quantitative analysis may also be performed by other methods of analysis, at the option of the Department. The manufacturer shall maintain a laboratory sufficiently staffed and equipped so as to maintain the quality of the product as called for in these specifications.

5.0 PREPARATION FOR DELIVERY

5.1 **Packaging:**

5.1.1 Block Form:

The thermoplastic material shall be packaged in suitable containers to which it will not adhere nor interact during shipment and storage. The blocks of cast thermoplastic material shall be approximately 35 by 12 by 2 inches and shall weigh approximately 50 lbs. The containers shall be palletized as specified in the contract or purchase order.

5.1.2 Granular Form:

The thermoplastic material shall be packaged in meltable bags which are compatible with the thermoplastic and which weigh approximately 50 lb when filled. The containers must have sufficient strength and be properly sealed to prevent breakage and leakage during normal handling. The bags shall be shrink-wrapped to reduce shifting of

the bags on the pallet and shall be palletized as specified in the contract or purchase order.

5.2 **Markings:**

Each individual unit/container of product shall be labeled. This label shall include: State Specification number (PTH-02PROFILE), color, type of binder, manufacturer's name and address, date of manufacture and batch number. Lead-free yellow materials shall be marked "Lead-Free". All markings on containers shall be legible and permanent. Markings shall not smear or rub off container. Containers failing to meet marking requirements will not be accepted.

The containers and labeling shall meet all applicable US Department of Transportation and Interstate Commerce Commission regulations. Concerning the content, each container shall be labeled with such warnings or precautions as are required by Local, State and Federal laws and requirements.

6.0 NOTES

6.1 **Certificates of Compliance:**

The manufacturer of thermoplastic materials shall furnish the Engineer with a Certificate of Compliance in conformance with the provisions of the California Department of Transportation Standard Specifications, latest revision, section 6-1.07, "Certificate of Compliance." The Certificate shall also include a list, by title and section, of all applicable State and Federal packaging and labeling laws and a statement that all requirements have been met. Certificates of Compliance shall be sent along with each delivery of thermoplastic and also with samples sent to the Transportation Laboratory for testing.

6.2 **Material Safety Data Sheets:**

Material Safety Data Sheets (MSDS's) shall be provided by the manufacturer with each delivery of thermoplastic. These MSDS's shall include health hazard information on the material when it is heated to application temperature 425°F.

6.3 **Patents:**

The Contractor shall assume all costs arising from the use of patented; materials, equipment, devices or processes used on or incorporated in the work, and further agrees to indemnify and save harmless the State of California and its duly authorized representatives from all suits at law or action of every nature for or on account of the use of any patented; materials, equipment, devices or processes.

6.4 **Contact Information:**

Please send the representative samples of each lot to,

California Department of Transportation
Transportation Laboratory – Chemistry Branch
5900 Folsom Blvd.
Sacramento, CA 95819

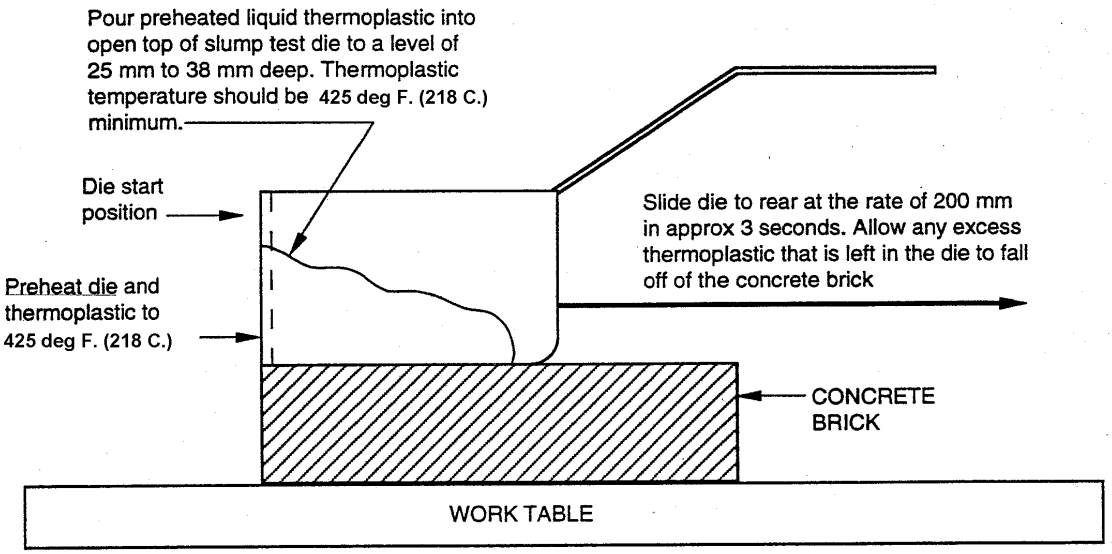
Attention: Andy Rogerson
Fax: (916) 227-7168

CALIFORNIA DEPARTMENT OF TRANSPORTATION
SPECIFICATION PTH-02PROFILE
File: PTH-02PROFILE (Feb. 06)
(APRIL 2003)

PROFILED THERMOPLASTIC SLUMP TEST PROCEDURE

(N.T.S.)

FIG. 1

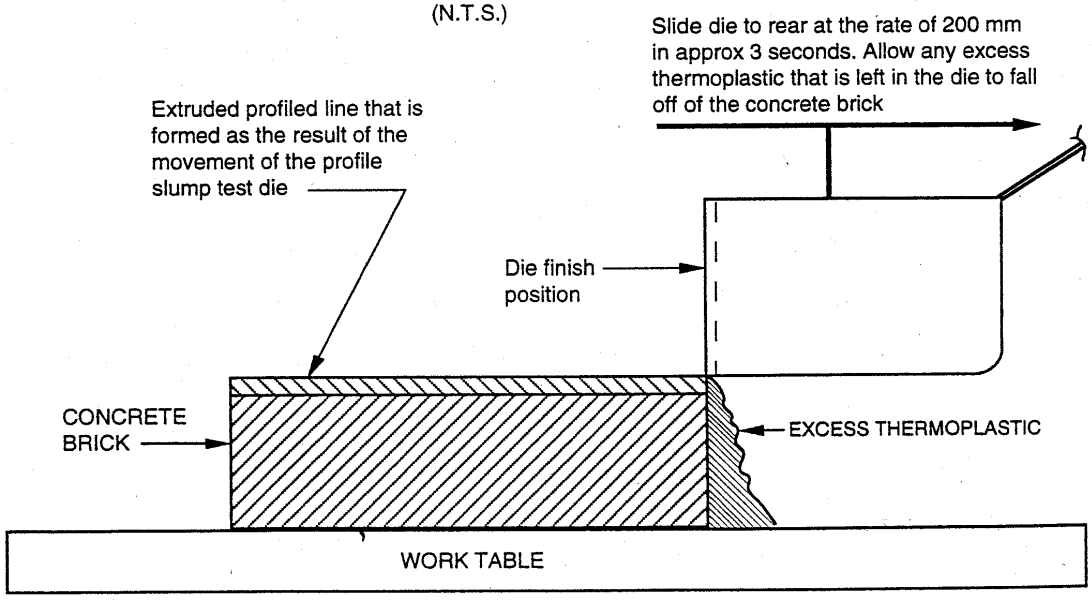


SIDE VIEW

PROFILED THERMOPLASTIC SLUMP TEST PROCEDURE

(N.T.S.)

FIG. 2

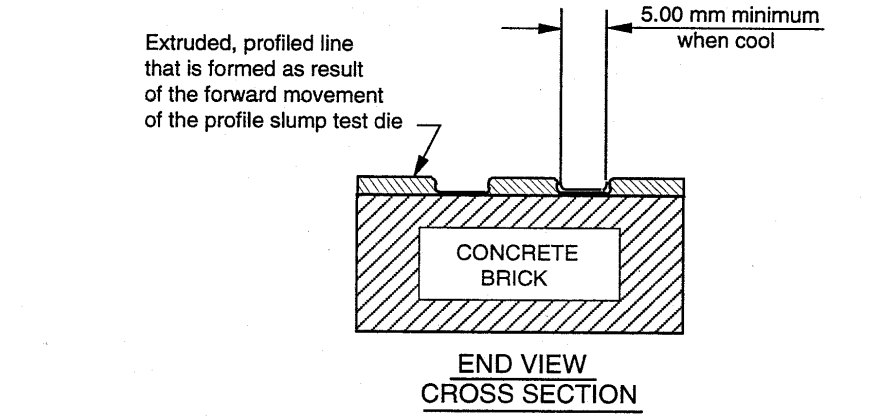


SIDE VIEW

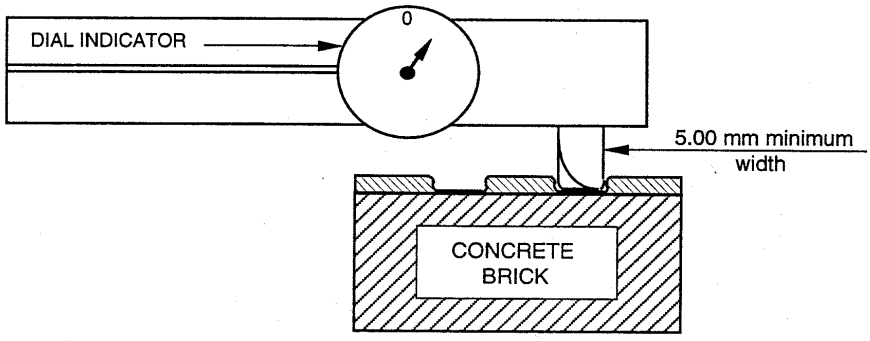
PROFILED THERMOPLASTIC SLUMP TEST PROCEDURE

(N.T.S.)

FIG. 3



END VIEW
CROSS SECTION

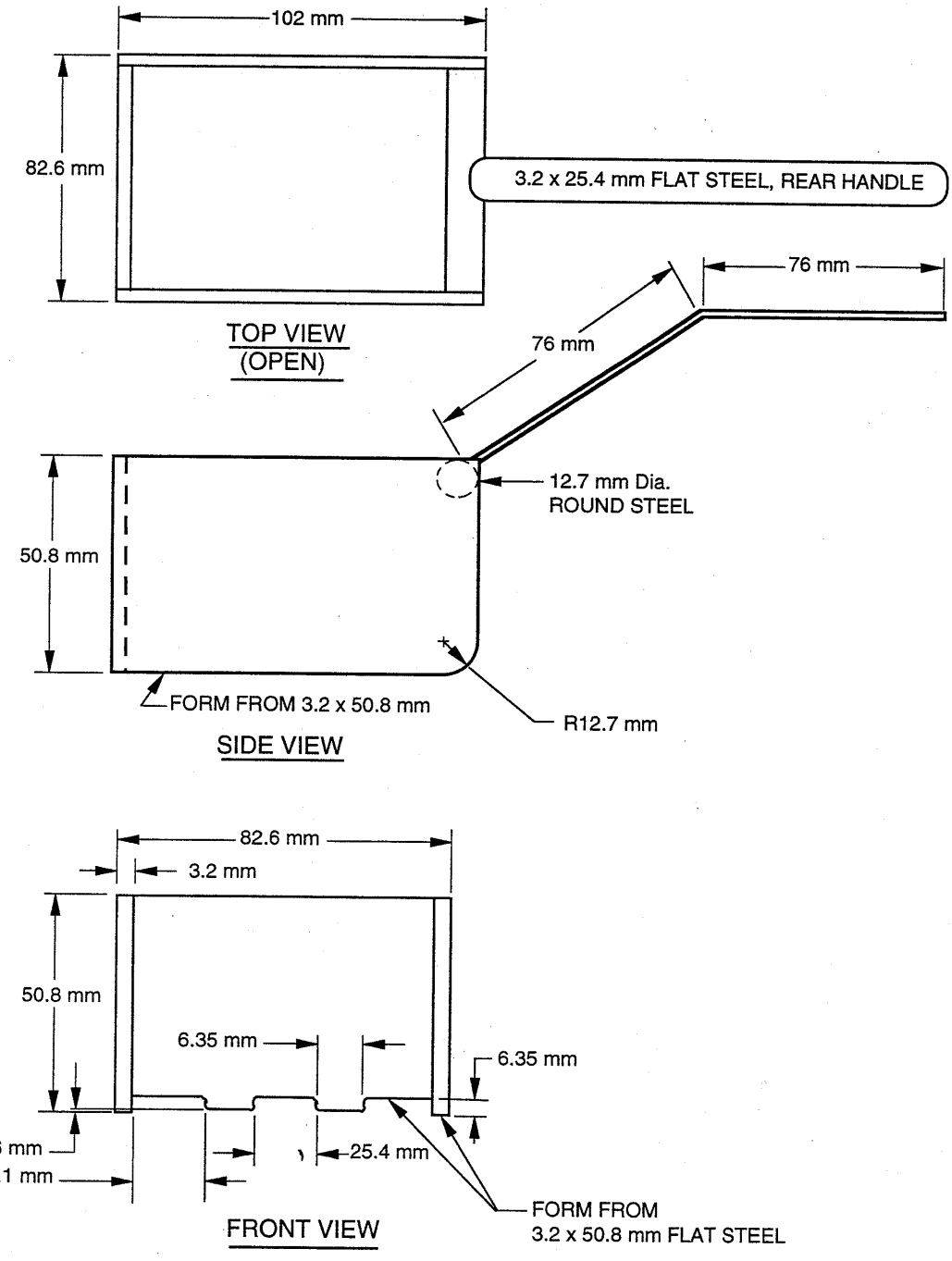


END VIEW
CROSS SECTION

PROFILED THERMOPLASTIC SLUMP TEST PROCEDURE

(N.T.S.)

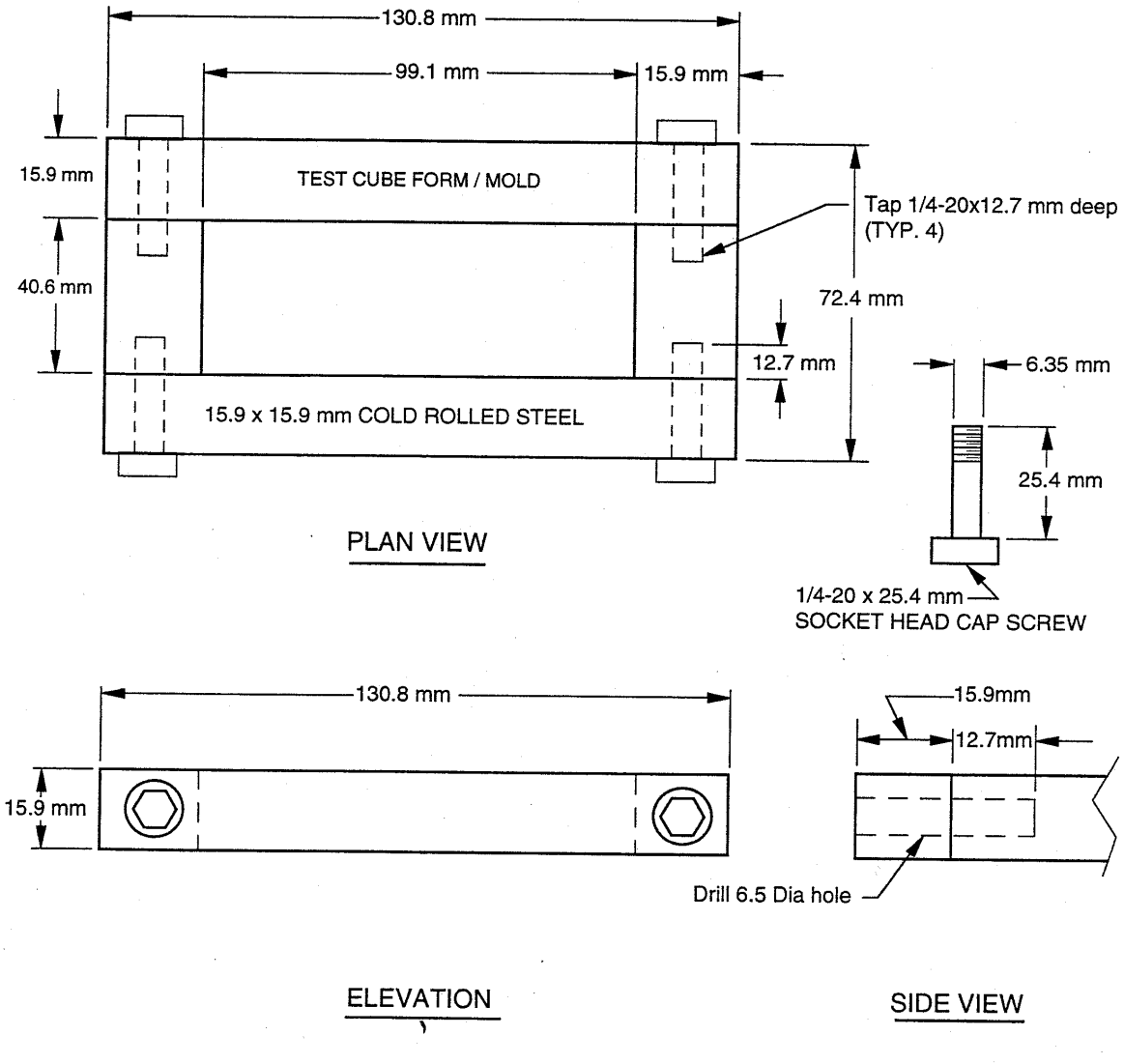
FIG. 4



PROFILED THERMOPLASTIC COMPRESSION TEST PROCEDURE

(N.T.S.)

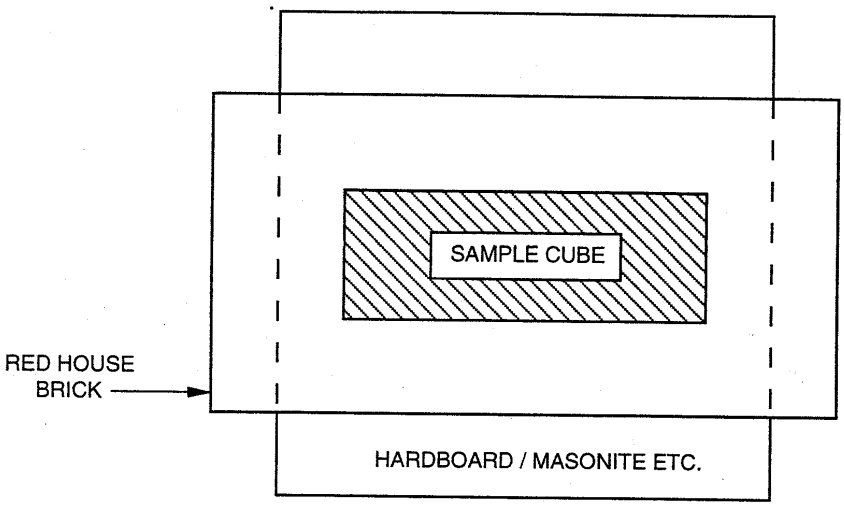
FIG. 5



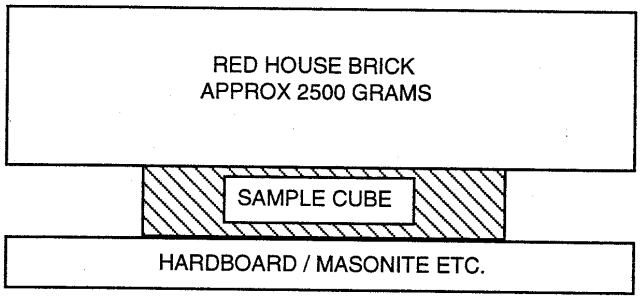
PROFILED THERMOPLASTIC COMPRESSION TEST PROCEDURE

(N.T.S.)

FIG. 6



PLAN VIEW

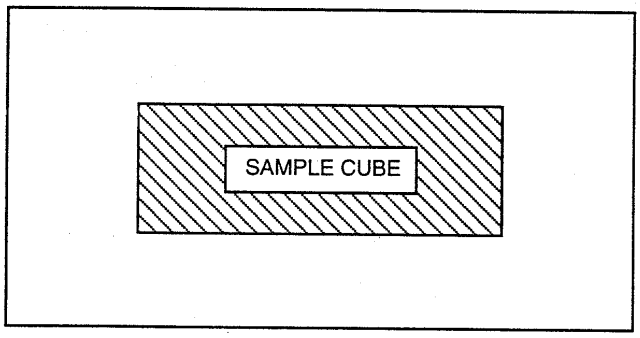


SIDE VIEW

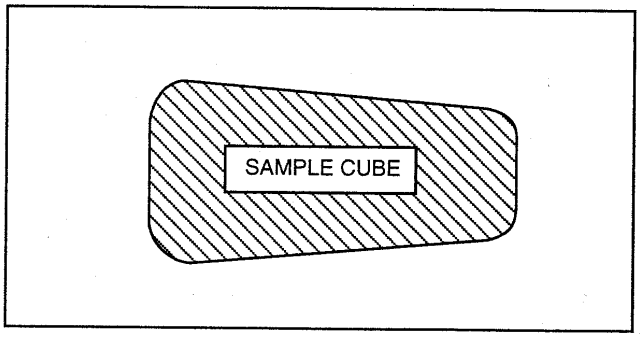
PROFILED THERMOPLASTIC COMPRESSION TEST PROCEDURE

(N.T.S.)

FIG. 7



AFTER TEST-TYPICAL PASS



AFTER TEST-TYPICAL FAIL

Melting/Stirring Equipment

Melting a Sample

Thermoplastic Melting and Stirring Equipment List

- Glas-Col, heating mantle, cat. #100D-DH098BC
- Arrow Engineering Co., air-powered stirrer motor, Model GG
- Arrow Engineering Co., Jacobs chuck adapter for 3/8" motor shaft, Part no. Jacobs #375
- Arrow Engineering Co., stirrer shaft 3/8"diam., 12" long, Part no. S-316-12
- Arrow Engineering Co. stirrer propeller, 5.25" diam., Part no. VPP316-52 (2 needed)
- Arrow Engineering Co. stirrer support stand with 5/8" diam. rod, Part no. ASE-625
- Arrow Engineering Co. power hold universal clamp, Part no. PHC-625
- Omega Engineering process temperature controller, Model #BS5001J1
- Omega Engineering, stainless steel sheathed thermocouple, Part no. TJ36-ICSS-18G-12
- 1-gal metal paint can with welded seam
- Lid to fit 1-gal. paint can (modified to allow passage of stirrer and thermocouple)
- Compressed air supply, ~80 psi

FIG. 8

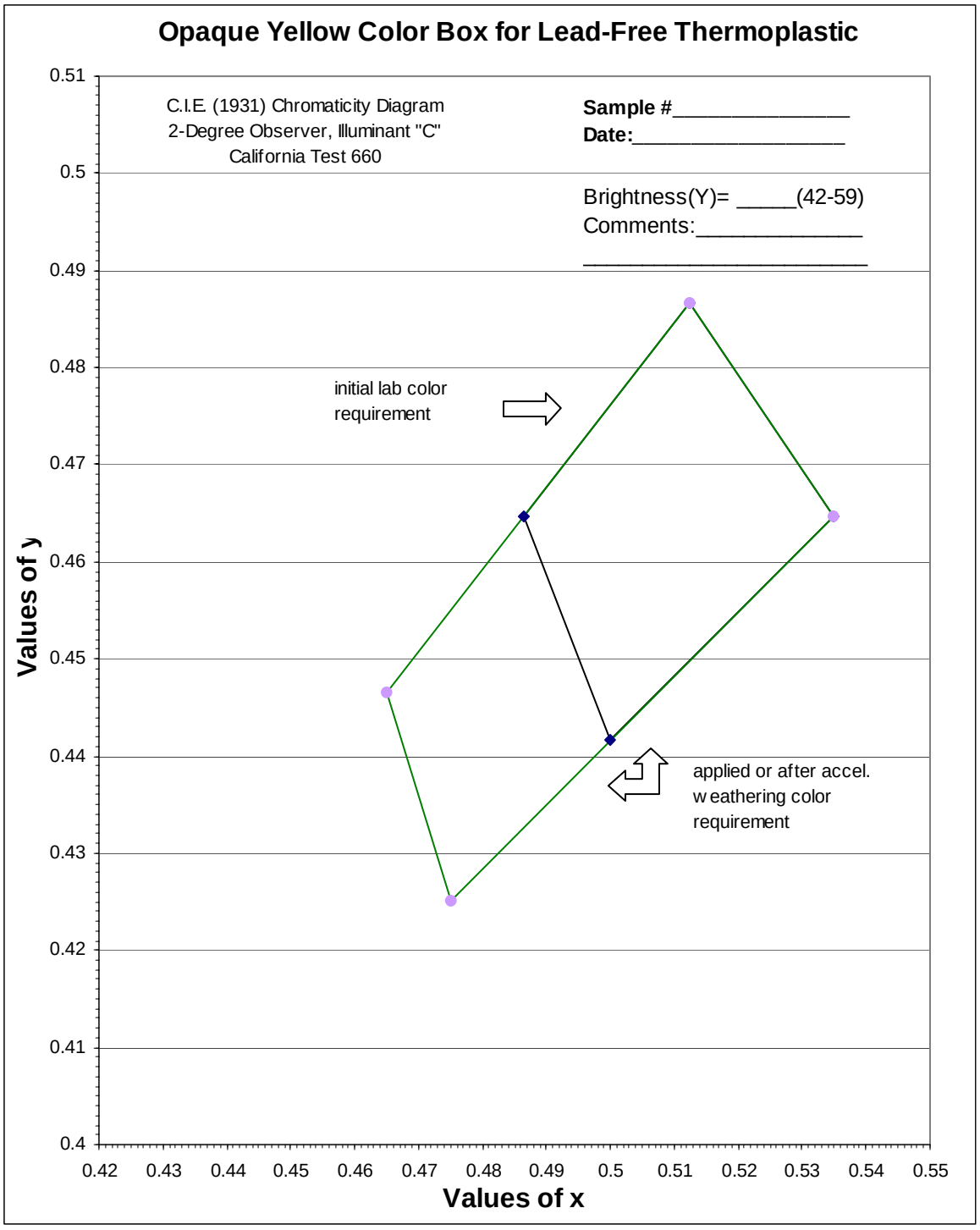


Chart for Plotting the Color of Yellow Thermoplastic

FIG. 9